

14.05 – INTERMEDIATE MACROECONOMICS

Problem Set 3, Fall 2025

Exercise 1

Consider a drug company that contemplates inventing a drug. The drug costs \$800 to invent. Once invented, it can be produced at a marginal cost of \$1 by the company that invented the drug as well as other drug companies. Suppose there are a large number of drug companies. The total market demand for the drug is described by the following relation:

$$x = 61 - p$$

where p is the price of the drug.

- a) Suppose the drug was invented and there are no intellectual property rights so all drug companies can produce the drug. Suppose these companies compete à la Bertrand (that is, they undercut each other's price whenever it is profitable to do so). What is the equilibrium price p^e and the equilibrium quantity produced x^e ? Does the original inventor make sufficient profit to recoup the costs of inventing the drug?
 - b) Now suppose there are strong intellectual property rights so that only the inventor can commercialize the drug. For simplicity, assume the inventor acts as a monopolist so it can choose the price p^m (and thus the quantity x^m). Calculate p^m , x^m and profits π^m . Does the original inventor make sufficient profit to recoup the costs of inventing the drug?
 - c) Compare the quantities produced in the previous two parts x^e and x^m . Is x^m greater or smaller than x^e ? Which one reflects a more efficient utilization of the drug (once invented)? Combine this with your analysis from the previous part to explain a key benefit and a key cost of IPR.
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- d) In the lecture, we discussed two additional mechanisms by which IPR can affect innovation incentives (different than the mechanism captured by this exercise). Briefly describe each mechanism, and explain how IPR affects the incentives to innovate [increase or decrease] through that mechanism.

Exercise 2

Suppose the economy has two factors: high-skilled labor and low-skilled labor. The production function takes the following special form

$$A_H H + A_L L$$

Here, H and L respectively denote the aggregate supply of high-skilled and low-skilled labor. Let w_H and w_L denote the corresponding wage levels. Answer the following questions based on the model of directed (or endogenously biased) technical change discussed in class.

- a) Derive the wage levels $\{w_H, w_L\}$ in terms of the parameters of the model. Characterize the skill premium w_H/w_L .
- b) Suppose the supply of low skilled labor L remains the same, while the supply of high skilled labor H increases (exogenously) due to greater schooling. How would this change affect high-skill augmenting technology relative to low-skill augmenting technology, A_H/A_L ? Why? How would the change affect the wage premium w_H/w_L ?
- c) Describe how you would apply the results from the previous part to explain the trends in labor income inequality in the US in recent decades.
- d) Read the paper by Saez (2017) on Canvas. The author argues that technology alone cannot explain the increase in top income shares in recent years. What is his argument? He proposes other factors that contribute to income inequality in recent years. Briefly (not to exceed one or two paragraphs) summarize the factors he proposes.

Exercise 3

This exercise connects our business-cycle modeling—and in particular the real business cycle (RBC) model seen in class—with our earlier phase diagram analysis in the neoclassical growth model. Specifically, consider the neoclassical growth model with production function $y = Ak^\alpha$ (as covered in class) and with the empirically relevant case of a low elasticity of intertemporal substitution in consumer preferences. Suppose the economy is initially at the steady-state. At date 0, the economy experiences a negative productivity shock so that TFP *permanently* decreases from A to some $A^{new} < A$.

- a) Draw the phase diagram that illustrates how the economy converges old steady-state to the new steady-state.²
- b) Analyze what happens to initial consumption $c(0)$, investment $i(0)$, output $y(0)$, wages $w(0)$, and the interest rate $r(0) = R(0) - \delta$.
- c) Which of these observations (if any) are qualitatively consistent with what happens in a typical recession in the US?

For the rest of the exercise, suppose instead that A is constant but the discount rate decreases *permanently* at date 0 from ρ to $\rho^{new} < \rho$. Note that this can be thought of as a negative “consumption demand shock” in the sense that, keeping all else (including in particular the path of interest rates) constant, households have a greater propensity to save (equivalently, they have a smaller propensity to spend).

- d) Analyze what happens to $c(0)$, $i(0)$, $y(0)$, $w(0)$, and $r(0)$. Does a negative consumption demand shock reduce consumption? Does it reduce output (or wages)?

Exercise 4

Consider a static RBC model, without capital, where the representative household maximizes utility

$$U(c_t, \ell_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{\ell_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}, \quad \sigma, \varphi > 0$$

over consumption and labor supply, subject to the budget constraint

$$c_t = w_t \ell_t$$

The representative firm hires labor and produces output

$$y_t = A \ell_t, \quad A > 0$$

where A denotes the level of productivity.

- a) Consider a competitive equilibrium where the representative household maximizes utility taking w_t as given, the representative firm maximizes profits taking w_t as given, and markets clear. Solve for equilibrium output y_t and employment ℓ_t . Does an increase in productivity A increase employment? Explain.

²Note that, differently from the RBC model covered in class, we here assume that labor is exogenously fixed, as in our earlier analysis of the neoclassical growth model.

- b) Suppose there is a government that exogenously consumes g_t units of output, unvalued by the household. The government runs a balanced budget with lump-sum taxes $T_t = g_t$ on the representative household. The representative household then has budget constraint $c_t = w_t \ell_t - T_t$ and the economy-wide resource constraint is

$$c_t + g_t = y_t$$

Calculate the effects of an exogenous increase in government consumption on output

$$\frac{dy_t}{dg_t}$$

Does an increase in g_t increase y_t more or less than 1-for-1? Explain.

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